SALTON SEA REVITALIZATION & RESTORATION

Salton Sea Authority Plan for Multi-Purpose Project

Air Quality Mitigation and Salt Management

Salton Sea Authority

September 2006

Background

The Salton Sea related State legislation enacted in 2003 as part of the QSA requires that (1) mitigation measures for the potential air-quality impacts created by the reduced inflows resulting from the QSA water transfer be included in the Agency's recommended preferred alternative project design and (2) the State assume financial liability for any required air-quality mitigation actions related to the QSA transfer that exceed the $133 million in mitigation costs paid by the QSA parties. Thus, air quality mitigation is a major consideration in the Agency's Ecosystem Restoration Project feasibility study as a matter of State law.

Air quality mitigation is a major consideration of the Authority and its member agencies because their constituents, i.e., the residents of the Coachella and Imperial Valley, will be the persons most affected by future poor air-quality conditions in the vicinity of the Salton Sea. In fact, air-quality impacts caused by the Salton Sea already are a regional issue due to the noxious odors which, depending on wind direction, carry as far as Palm Springs, Borrego Springs, and Calexico. Thus, the Authority's aggressive phosphorus source-control program that is designed to transition the eutrophic State of the Sea back to its non-odorous State as existed in the 1950s and 60s is an integral component of the Authority's air-quality management plan.

Air Basin Setting

The air quality issue that has drawn the most attention is the possibility of blowing dust storms caused by exposed sea-bed sediments. Many people make a direct comparison between the Salton Sea and the Owens Valley with respect to potential dust-emission problems and mitigation costs (Pacific Institute, 2006; Salton Sea Coalition, 2006; and comments at various State Advisory Committee meetings). The Agency has based the air-quality management approach in its Ecosystem System Restoration study on the explicit premise that "Owens Valley is the Working Model" (CH2M Hill, 2005).

These assumptions on the similarity of likely air quality issues at the Salton Sea and Owens Valley are directly contradicted by the facts and findings made by IID and Reclamation in their certified EIR/EIS for the Transfer Project QSA:

To further consider the potential impact for emissions from the Salton Sea, a comparison was made to existing dry lake beds where dust impacts have been observed. <u>Fortunately, conditions found to produce dust storms on dry salt lake beds, such as Owens Lake, were not found to be present at the Salton Sea.</u> The following three primary factors would be expected to make the situation at the Salton Sea much less severe than at Owens Lake:

- ***Soil chemistry***: *…The soil system at the Salton Sea is predominately sodium sulfate and sodium chloride. These salts do not change in volume significantly with fluctuations in temperature, so the crust at the Salton Sea should be fairly stable and resistant to erosion. This anticipated situation at the Salton Sea is different from similar current situations at Owens and Mono Lakes, where a significant portion of the salinity is in the form of carbonates. The volume of carbonate salts is much more sensitive to temperature fluctuations, and desiccation of these salts produces fines that are readily suspended from playa at these lakes. Therefore, the salt crust on the exposed playa at the Salton Sea should be more stable and less emissive than Owens Lake. Also, distribution of mobile sand on the dry lakebed at Owens Lake is part of what drives high emissions rates, and comparable conditions are not expected at the Salton Sea.*

- ***Meteorology***: *The frequency of high wind events at the Salton Sea is less than at Owens Lake. Therefore, the dust storms at the Salton Sea would be less frequent than at Owens Lake. …The predominant wind direction at the Salton Sea is also favorable; during high wind events at the Sea, it is from the west and northwest, perpendicular to the orientation of the playa. Dust suspension on the playa of the Salton Sea would be higher if the playa were oriented parallel to the predominant wind direction.*

- ***Recession Rate***: *The anticipated decline in water levels at the Salton Sea is predicted to be significantly slower than what occurred at Owens Lake (only about 20 percent as fast). Natural processes may contribute more to controlling dust emissions at the Salton Sea than they have at Owens. These natural processes could include (a) the enabling of vegetation through development of soil conditions favorable to plant growth (including improvement in natural drainage), (b) development of native plant communities; (c) sequestration of sand into relatively stable dunes; and (d) formation of relatively stable crusts. [CH2M Hill, 2002, pp. 3.74-34/35, emphasis added].*

The above key findings in the EIS/EIR for the Transfer Project/QSA were supported and upheld by the State Board in the water rights order its issued for the QSA transfers. These legal determinations are supported by the fundamental historical and geological differences between the Owens Valley and the Salton as noted by the Lahontan Regional Water Quality Control Board (2005):

Only since the 1913 export of water [to Los Angeles] has a saline playa existed … the salt deposit on the [Owens Lake] playa surface is thin, and has been formed by the evaporation of saline groundwater rather than from the desiccation of the historic lake.

The opposite is true in the case of the Salton Sea. Areas exposed by receding water levels of the Salton Sea will become covered by desiccated agricultural drainage salt deposits; not indigenous salts leached from soil matrix. This difference is significant because it is the uniqueness of the indigenous salts in the Owens Valley that accounts for the area's notorious air quality problem. This fact is also Stated by Lahontan Region Water Quality Control Board (2005):

Owens Lake is the largest single source of particulate air pollution in the United States. <u>This situation is related to the lake's salt chemistry</u>. The salt crust on the playa contains a higher proportion of sodium carbonate [soda ash], sodium bicarbonate [baking soda] and sodium sulfate salts than most other playas in California. Most other plays are strongly dominated by sodium chloride salt (halite) [table salt]. Halite does not undergo the dramatic volumetric phase change that [sodium] carbonate and sulfate salts do on Owens Lake. <u>These [volumetric phase] changes break apart the playa surface and allow salts to be easily suspended by the winds."</u> [emphasis added]

Proposed Air Mitigation Approach

Thus, rather than being concerned about lakebed soil emissivity (the focus of the Agency's air mitigation approach), the pertinent concern in assessing the potential for air quality impacts at the Salton Sea is the **friability of desiccated salts that will be deposited on the surface of the exposed lakebed as the sea recedes**. As shown in the graph in Figure 1, the carbonate salts (Na_2CO_3 and $NaHCO_3$) that are the known cause for the air quality problems at Owens Valley account for 60% to 83% of the total salt in the salt deposits that formed during evaporation tests. Note that in these data that sodium chloride salt (NaCl) – the type of salt most prevalent at the Salton Sea -- was only 10% to 20% in these tests.

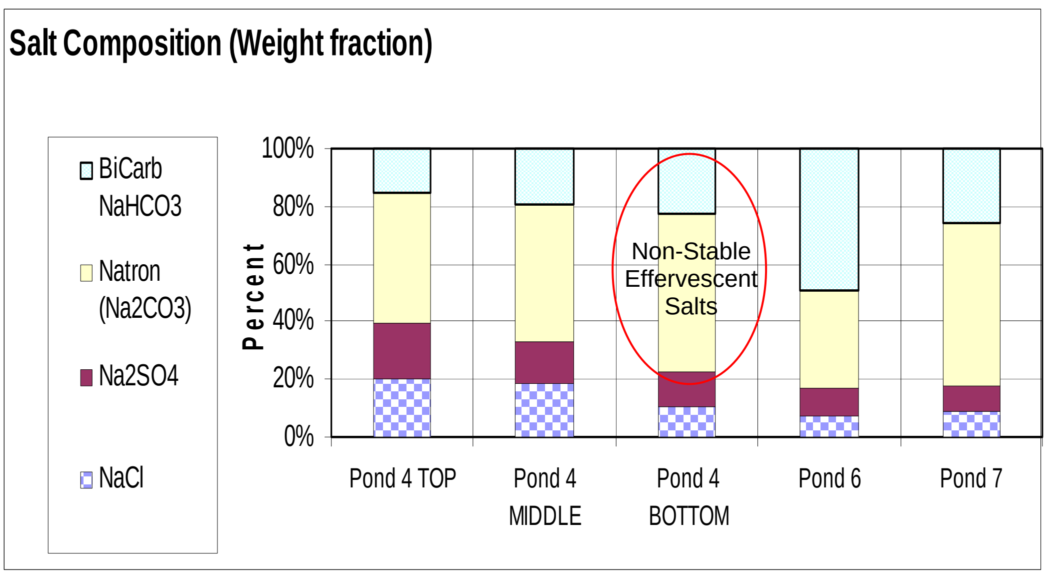

Figure 1. Salt Chemistry from Evaporation Tests at Owens Valley: Agrarian Research.

The Authority has conducted salt pond evaporation tests on Salton Sea water. The same firm (Agrarian Research) that performed the Owens Valley salt evaporation tests performed the Salton Sea test. After first concentrating the salts in the Salt Sea water by a factor of 3x to 4x (which would be equivalent to running it through the saline habitat complex in the Authority project design), the concentrate was placed into crystallizer cells (the equivalent to shallow impoundment ponds in the south basin in the Authority project design) and allowed to dry into a solid. The chemistry of these salt deposits formed from the concentrated Sea water is shown in Figure 2.

	$CaSO_4$	$MgSO_4$	Na_2SO_4	NaCl	KCl
Salt	1.06	4.28	4.51	89.81	0.32

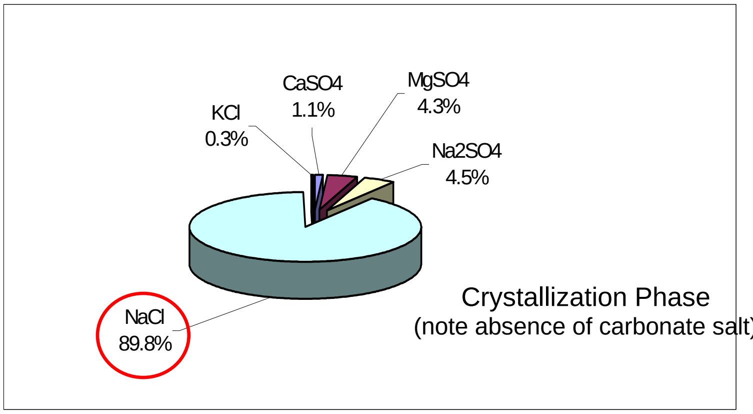

Figure 2. Salt Chemistry from Evaporation Tests at Salton Sea. Source: Agrarian Research.

The key figure in Figure 2 is the 90% sodium chloride (NaCl), plain table salt. The commercial salt industry is familiar with the techniques and procedures involved in operating crystallizer basins for growing NaCl salt crystals from seawater or brackish water while washing away other unwanted salts (like sodium sulfate). Agrarian Research used these same techniques to grow the NaCl crystal from Salton Sea water shown in Figure 3.

Figure 3. NaCl Salt Crystal formed from Salton Sea water.
Source: Agarian Research

Given the large quantity of salt in the Salton Sea (over 400 million tons – enough to cover the Sea's entire 360 sq. mile surface area with a 14-inch thick solid deposit) and realizing that 90% of this salt (after concentration) is NaCl that dries into hard crystals, the Authority advanced the concept of using naturally formed NaCl deposits to cover exposed areas in the south basin in the Authority project design as an air quality mitigation measure. The Authority had previous experience forming large, stable salt deposits from Salton Sea water from the solar evaporator tests it conducted with Reclamation in 2000-02 (Figure 4).

Figure 4. Thick Salt Deposit formed from Sea water during solar evaporator tests in 2002. (Authority photo)

To confirm the practicality and efficacy of using naturally formed salt deposits for air-quality mitigation, the Authority engaged a salt industry expert (John Pyles). Before his retirement, Mr. Pyles managed the 40,000-acre Cargill commercial salt pond complex in San Francisco Bay. He had also previously worked as a consultant on a Salton Sea project. In his letter to the Authority, Mr. Pyles States that in his 21 years of work at the Cargill salt complex in San Francisco Bay:

The company never experienced any blowing dust or other air quality problems, including odor complaints while the crystallizers were in operation. New housing developments and commercial buildings were built within 1 mile of the solar ponds on both ends of the Dumbarton Bridge without any dust or odors being an issue (Pyles, 2006).

After familiarizing himself with the Authority project design and recent work by Agrarian Research, Mr. Pyles expressed the following expert opinion:

A managed salt deposit with such a high content of NaCl would be competent and highly cemented body capable of supporting repeated use of heavy equipment if desired. This characteristic is seen all over the world in salt deposits high in sodium chloride content, *regardless of other co-precipitated salt. I believe that forming a thick, competent deposit high in NaCl on top of the exposed areas within the south basin in the Authority Plan is a well proven concept that is both feasible and technically sound.* (Pyles, 2006.)

A photograph of the cemented, durable (4-year-old) surface of an experimental 5-acre salt deposit formed from Sea water is shown in Figure 5. For comparison, a photograph of the expansive salt deposits within the 200-sq. mile old Laguna Salada lakebed (also part of the ancient Colorado River delta) is shown in Figure 6. In terms of salt chemistry and local hydrologic, geologic and climatic factors affecting the characteristics of the salt deposits that will form when the Salton Sea drys down, the Sea is more analogous to its historic relative, the Laguna Salada, about 50 miles away in Mexico; than the dry Owens Lake bed, 250 miles away in a very different climatic, hydrologic, and geologic setting. As a cemented salt deposit as referred to in Mr. Pyles' letter, the Laguna Salada does not have a blowing dust problem.[1]

To determine the area within the south basin that will eventually become covered with a naturally formed NaCl salt deposit as the water level in the south basin recedes, Tetra Tech developed a model to calculate (1) the decline in water elevation in the south basin based on the inflow reduction scenario presented in Chapter 3, and (2) the elevation at which the salt concentration in the south basin will exceed the precipitation point for NaCl. These projections are shown in Figures 6 and 7. Under this scenario, the model shows that hypersalinity (defined to be the salt concentration at which NaCl precipitates) would reach the –255-ft msl elevation in 2023 (i.e., about 10 years after construction of the in-Sea barrier is completed).

The map shown in Figure 7 illustrates the –255-ft msl contour line inside the south basin. The area within this contour will be covered with either (1) a cemented NaCl salt deposit or (2) the semi-solid brine pool. Of the 90,000 acres in the south basin (excluding the habitat complex and water storage reservoir), the modeling shows that only about 7,000 acres—less than 8% -- *may* have a possible exposure problem. This area is the strip between the west barrier and the -250-ft msl contour. Even this area is unlikely to experience dust problems for these reasons:

- It will be at the toe of the in-Sea barrier where there will be seepage or thus the likelihood of natural vegetation growing;
- This area is isolated from public exposure by a surrounding water body; and
- This location lies 20-to-25 feet below the surface water of the surrounding lake which again suggest seepage and natural vegetation will occur.

[1] Mexicali has held concerts attended by 40,000 people at the Laguna Salada (info@TourMexico.com) and two Federal highways cross the salt flats.

Figure 5. Experimental Salt Deposit Formed from Salton Sea Water.

Figure 6. Salt Deposits on old Laguna Salada Lakebed near Mexicali.

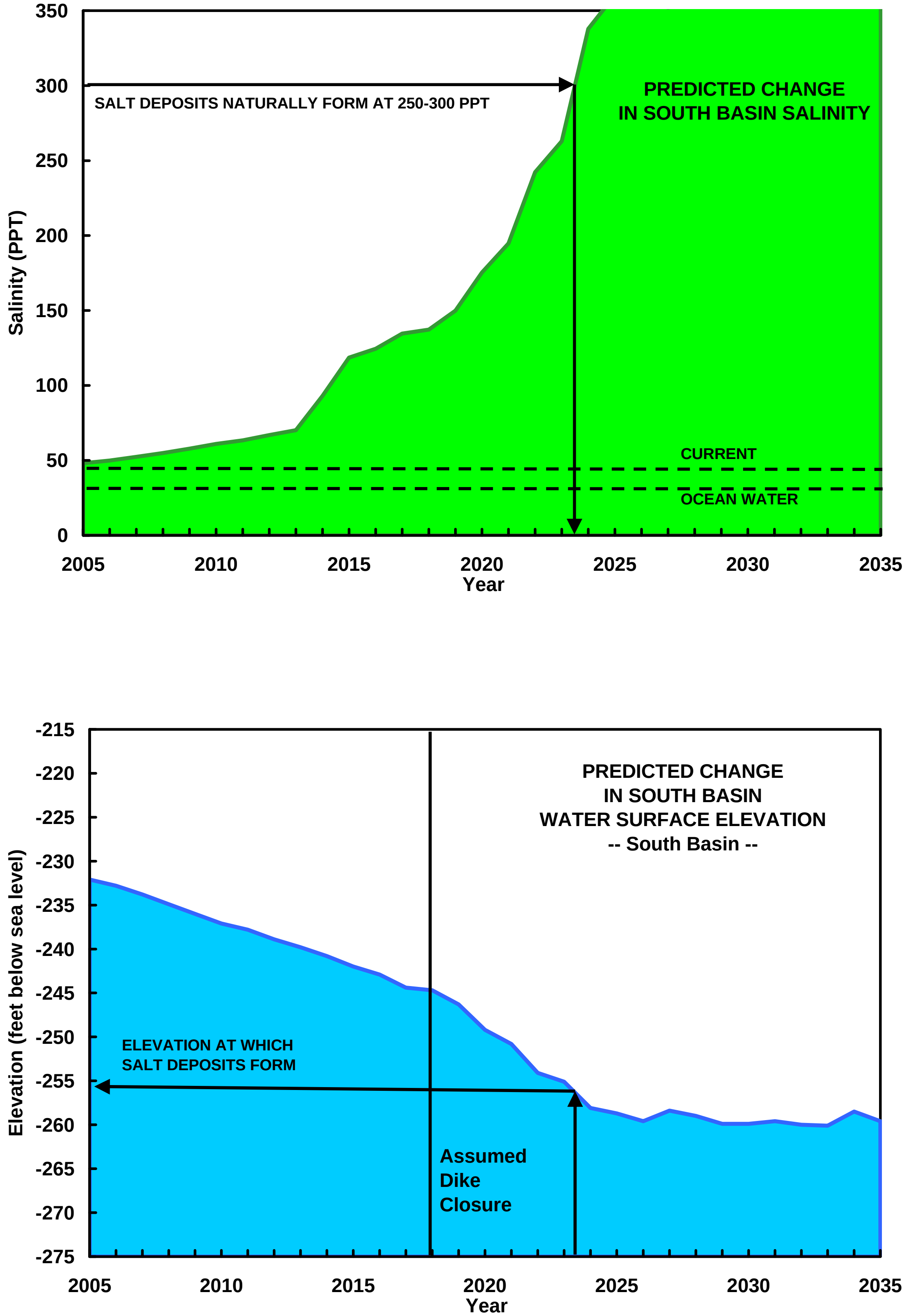

Figure 7. Predicted Salinity and Elevation in the South Basin Brine Pool.

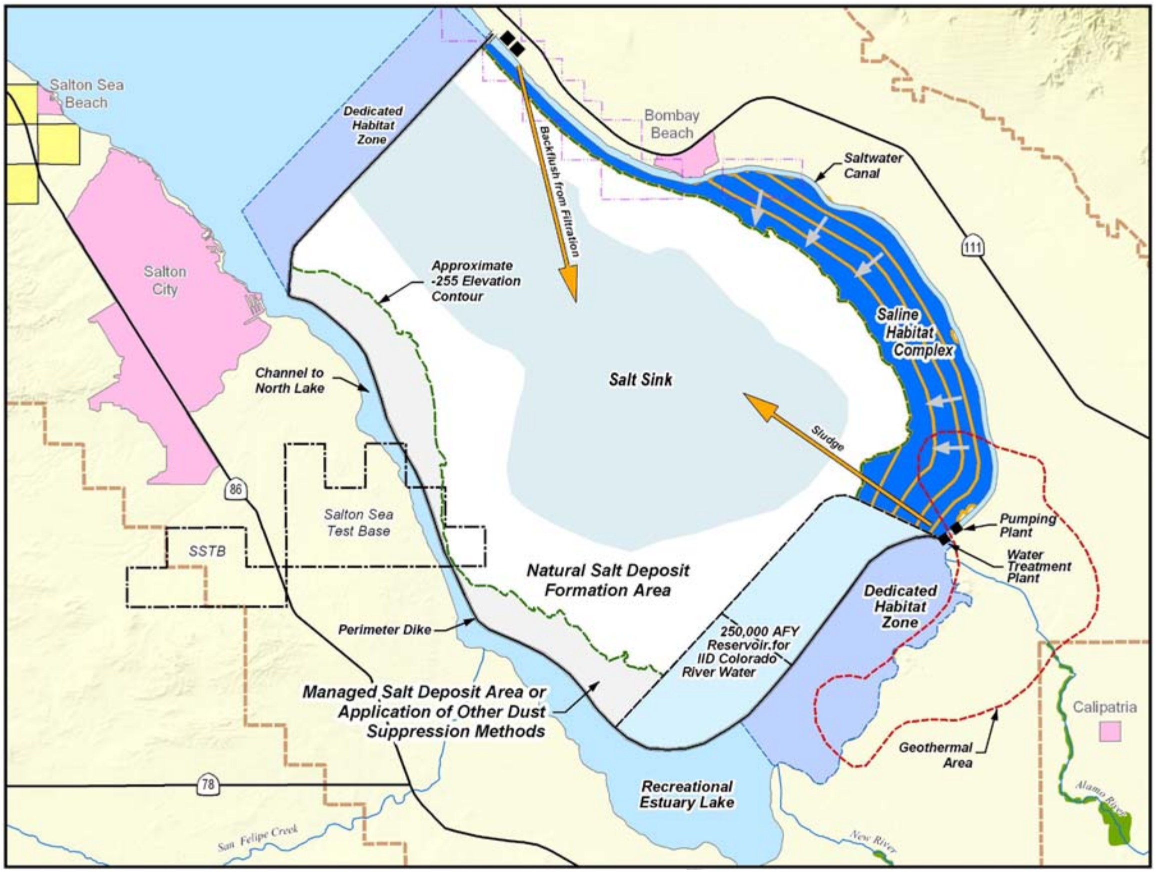

Figure 8. Map Showing Natural Salt Deposit Formation Area.

If blowing dust is a problem in this small area, magnesium chloride from the brine pool could be pumped to form a protective chemical cover as is commonly done as an air-quality mitigation measure at construction sites. Other mitigation measures will be applied as necessary and appropriate based techniques developed by the State as part of its Ecosystem Restoration Study "tool box" and future pilot projects. Over time, salt deposit management and maintenance will be required as suggested by Mr. Pyles in his letter.

References

CH2M Hill. 2002. IID Water Conservation and Transfer Project Draft Environmental Impact Report/Environmental Impact Statement.

Pacific Institute, 2006 (Michael Cohen). Hazard: The Future of the Salton Sea with No Restoration Project. May.

Pyles, John. 2006. Letter from John Pyles, Applied Solar Technologies, to Ronald Enzweiler, Salton Sea Authority. March 20th. (provided on following pages)

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March 20, 2006

Ronald Enzweiler
Executive Director
Salton Sea Authority

Dear Mr. Enzweiler,

Thank you for giving me the opportunity to become reinvolved in the Salton Sea restoration effort. I was previously involved in the Salton Sea as a team member on the Parsons' "Analysis of Restoration Options" independent technical review study conducted in 2000, and on the subsequent Agrarian Research solar-pond pilot project.

I have been working professionally in the solar salt industry since 1977. I currently consult worldwide on salt, including environmental projects that remove salts from an area or process. My professional experience includes managing the operations of the 40,000 acres of commercial solar salt ponds that were located in San Francisco Bay. These facilities produced 1,250,00 tons/year of 99% pure sodium chloride (NaCl) salt by the controlled evaporation of San Francisco Bay water (which contains about 10,000 mg/L of total dissolved solids). In my 21 years of work at these Cargill facilities, we never experienced blowing dust or other air quality problems, including odor complaints in the salt crystallizers while in operation. New housing developments and commercial buildings were built within 1 mile of these solar ponds on both ends of the Dumbarton Bridge without dust or odors being an issue.

You have presented an overview to me of the current Salton Sea Authority (SSA) plan. That plan includes maintaining the current water level over most of the existing shoreline, and addresses odors, salinity and other water quality and habitat issues. A major feature of the plan is to create an isolated brine pool and salt deposit area by installing a perimeter dike around the south end of the current Sea.

The Agrarian Research (AR) project and the work done by the Bureau of Reclamation at the Salton Sea Test Base demonstrate conclusively that a thick salt deposit can be made from Salton Sea water. The AR test results show that 1.6 ft of deposit can be made in one year and that about 1 ft can be deposited during the warm months in a managed salt crystallizer pond. The solids deposited were about 87% NaCl. This thickness and quality could be duplicated in the exposed areas within the south basin in the current SSA project plan. With further work, there is a possibility that the percentage of hard-surface NaCl salt in the protective salt desposits can be increased to improve the durability of this low-cost dust-control mitigation measure. The technique to achieve a high NaCl content in the protective salt deposits in the SSA Plan would be the same as the techniques used in the commercial solar salt industry, namely: once the salinity in the crystallizer ponds reaches a certain point, the remaining supernatant (i.e., the brine containing the sodium sulfate salt and other more soluble salts) would be decanted off and channeled into the brine pool that will form and permanently exist in the lower depths of the south basin. Rain could also be a mechanism for purifying the salt deposit by removing the more soluble sodium sulfate that can co-precipitate with the sodium chloride. This would require establishing a method of draining away entrained brine in the selected areas. The approach would require the construction of berms at 3-to-5 ft contour levels around the upper areas of the south basin. However, given the layout of the SSA Plan, these "terraced" crystallizer basins could be fed by gravity from the brine outflow at the foot of the Saline Habitat Complex (SHC) located along the upper eastern perimeter of the south basin. Thus, pumping and other O&M costs to form a thick salt deposit in the lower exposed areas of the south basin would be minimal.

A managed salt deposit with such a high content of NaCl would be a competent and highly cemented body capable of supporting repeated use of heavy equipment if desired. This characteristic is seen all over the world in salt deposits high in sodium chloride content, regardless of the other co-precipitated salts. I believe that forming a thick, competent deposit high in NaCl on top of the exposed areas within the south basin in the SSA Plan is a well proven concept that is both feasible and technically sound.

Any salt deposit exposed to the elements will require some maintenance. This is part of managing the deposit. Occurrences such as localized upwelling, seepage from the dike, and rain can dissolve the salt deposit. Upwelling and seepage tend to be localized in their effects, while rain is more generalized in its effect. There are established methods for both reducing seepage and upwelling at their source, and negating the adverse effects of either. Although rain at less than 3 inches per year is minimal, it would eventually remove enough of any deposit to require reestablishing the salt layer. The salt desposit could be reestablished simply by refilling each crystallizer basin with brine from the SHC outflow and decanting the supernatant on a periodic, "as required" basis. Based on my professional experience, I see this rebuilding operation being required on roughly 10-year or longer cycles.

Thank you again for giving me the opportunity to work with you on the Salton Sea restoration project. Please let me know if you have any questions or would like for me to perform further work on this assignment.

Regards,

John Pyles

cc: William Brownlie, Tetra Tech